APPENDIX E

EQUATIONS AND PARAMETER VALUES FOR CALCULATING COPC-SPECIFIC MEDIA CONCENTRATIONS

(80 Pages)

APPENDIX E

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LIST OF VARIABLES AND PARAMETERS

$($	=	Empirical constant (unitless)
δ_z	=	Dimensionless viscous sublayer thickness (unitless)
$:_a$	=	Viscosity of air (g/cm-s)
$:_w$	=	Viscosity of water corresponding to water temperature (g/cm-s)
Δ_a	=	Density of air (g/cm^3 or g/m^3)
Δ_w	=	Density of water corresponding to water temperature (g/cm^3)
2	=	Temperature correction factor (unitless)
2_{bs}	=	Bed sediment porosity (L volume/L sediment)—unitless
2_{sw}	=	Soil volumetric water content (mL water/cm^3 soil)
a	=	Empirical intercept coefficient (unitless)
A	=	Surface area of contaminated area (m^2)
A_{beef}	=	Concentration of COPC in beef (mg COPC/kg FW tissue)
$A_{chicken}$	=	Concentration of COPC in chicken meat (mg COPC/kg FW tissue)
A_{egg}	=	Concentration of COPC in eggs (mg COPC/kg FW tissue)
Ah	=	Area planted (m^2)
Ah_i	=	Area planted to *i*th crop (m^2)
A_I	=	Impervious watershed area receiving COPC deposition (m^2)
A_L	=	Total watershed area receiving COPC deposition (m^2)
A_{milk}	=	Concentration of COPC in milk (mg COPC/kg FW tissue)
A_{pork}	=	Concentration of COPC in pork (mg COPC/kg FW tissue)
A_W	=	Water body surface area (m^2)
b	=	Empirical slope coefficient (unitless)
Ba_{beef}	=	Biotransfer factor for beef (day/kg FW tissue)
$Ba_{chicken}$	=	Biotransfer factor for chicken (day/kg FW tissue)
Ba_{eggs}	=	Biotransfer factor for chicken eggs (day/kg FW tissue)
BAF_{fish}	=	Bioaccumulation factor for COPC in fish (L/kg FW tissue)
Ba_{milk}	=	Biotransfer factor for milk (day/kg FW tissue)
Ba_{pork}	=	Biotransfer factor for pork (day/kg FW tissue)
$BCF_{chicken}$	=	Bioconcentration factor for COPC in chicken (mg COPC/kg FW tissue)/(mg COPC/kg feed)—unitless
BCF_{egg}	=	Bioconcentration factor for COPC in eggs (mg COPC/kg FW tissue)/(mg COPC/kg feed)—unitless
BCF_{fish}	=	Bioconcentration factor for COPC in fish (mg COPC/kg FW tissue)/(mg COPC/kg dissolved water)—unitless
BD	=	Soil bulk density (g soil/cm^3 soil)
Br_{ag}	=	Plant-soil bioconcentration factor for aboveground produce (mg COPC/kg DW plant)/(mg COPC/kg soil)—unitless
$Br_{forage/silage/grain}$	=	Plant-soil bioconcentration factor for forage, silage, and grain (mg COPC/kg DW plant)/(mg COPC/kg soil)—unitless
$Br_{rootveg}$	=	Plant-soil bioconcentration factor for belowground produce (mg COPC/kg DW plant)/(mg COPC/kg soil)—unitless
Bs	=	Soil bioavailability factor (unitless)
$BSAF$	=	Biota-sediment accumulation factor (mg COPC/kg lipid tissue)/(mg COPC/kg sediment)—unitless

APPENDIX E

LIST OF VARIABLES AND PARAMETERS (Continued)

Bv_{ag}	=	COPC air_to_plant biotransfer factor for aboveground produce (mg COPC/kg DW plant)/(mg COPC/kg air)—unitless
Bv_{forage}	=	Airtoplant biotransfer factor for COPC in forage (mg COPC/kg DW plant)/(mg COPC/kg air)—unitless
c	=	Junge constant = 1.7×10^{-4} (atm_cm)
C	=	USLE cover management factor (unitless)
C_a	=	Air concentration (µg/m^3)
C_{acute}	=	Acute air concentration (µg/m^3)
C_{BS}	=	Bed sediment concentration (or bed sediment bulk density) (g/cm^3 or kg/L)
C_d	=	Drag coefficient (unitless)
C_{dw}	=	Dissolved phase water concentration (mg COPC/L water)
C_{fish}	=	Concentration of COPC in fish (mg COPC/kg FW tissue)
C_{hp}	=	Unitized hourly air concentration from vapor phase (µg-s/g-m^3)
C_{hv}	=	Unitized hourly air concentration from particle phase (µg-s/g-m^3)
Cs	=	Average soil concentration over exposure duration (mg COPC/kg soil)
C_{sb}	=	Concentration sorbed to bed sediment (mg COPC/kg sediment)
Cs_{tD}	=	Soil concentration at time tD (mg COPC/kg soil)
C_{wctot}	=	Total COPC concentration in water column (mg COPC/L water column)
C_{wtot}	=	Total water body COPC concentration including water column and bed sediment (g COPC/m^3 water body) or (mg/L)
Cyp	=	Unitized yearly average air concentration from particle phase (µg-s/g-m^3)
Cyv	=	Unitized yearly average air concentration from vapor phase (µg-s/g-m^3)
$Cywv$	=	Unitized yearly (water body or watershed) average air concentration from vapor phase (µg-s/g-m^3)
D_a	=	Diffusivity of COPC in air (cm^2/s)
d_{bs}	=	Depth of upper benthic sediment layer (m)
Ds	=	Deposition term (mg COPC/kg soil-yr)
d_{wc}	=	Depth of water column (m)
D_w	=	Diffusivity of COPC in water (cm^2/s)
$Dydp$	=	Unitized yearly average dry deposition from particle phase (s/m^2-yr)
$Dytwp$	=	Unitized yearly (water body or watershed) average total (wet and dry) deposition from particle phase (s/m^2-yr)
$Dywp$	=	Unitized yearly average wet deposition from particle phase (s/m^2-yr)
$Dywv$	=	Unitized yearly average wet deposition from vapor phase (s/m^2-yr)
$Dywwv$	=	Unitized yearly (water body or watershed) average wet deposition from vapor phase (s/m^2-yr)
d_z	=	Total water body depth (m)
ER	=	Soil enrichment ratio (unitless)
E_v	=	Average annual evapotranspiration (cm/yr)
f_{bs}	=	Fraction of total water body COPC concentration in benthic sediment (unitless)

APPENDIX E

LIST OF VARIABLES AND PARAMETERS (Continued)

Fd	=	Fraction of diet that is soil (unitless)
F_i	=	Fraction of plant type *i* grown on contaminated soil and ingested by the animal (unitless)
f_{lipid}	=	Fish lipid content (unitless)
Fw	=	Fraction of COPC wet deposition that adheres to plant surfaces (unitless)
f_{wc}	=	Fraction of total water body COPC concentration in the water column (unitless)
F_v	=	Fraction of COPC air concentration in vapor phase (unitless)
H	=	Henry's Law constant (atm-m^3/mol)
I	=	Average annual irrigation (cm/yr)
k	=	Von Karman's constant (unitless)
K	=	USLE erodibility factor (ton/acre)
k_b	=	Benthic burial rate constant (yr^{-1})
Kd_{bs}	=	Bed sediment/sediment pore water partition coefficient (cm^3 water/g bottom sediment or L water/kg bottom sediment)
Kd_s	=	Soil-water partition coefficient (cm^3 water/g soil)
Kd_{sw}	=	Suspended sediment-surface water partition coefficient (L water/kg suspended sediment)
K_G	=	Gas phase transfer coefficient (m/yr)
K_L	=	Liquid phase transfer coefficient (m/yr)
K_{oc}	=	Soil organic carbon-water partition coefficient (mL water/g soil)
K_{ow}	=	Octanol-water partition coefficient (mg COPC/L octanol)/(mg COPC/L octanol)—unitless
kp	=	Plant surface loss coefficient (yr^{-1})
ks	=	COPC soil loss constant due to all processes (yr^{-1})
kse	=	COPC loss constant due to soil erosion (yr^{-1})
ksg	=	COPC loss constant due to biotic and abiotic degradation (yr^{-1})
ksl	=	COPC loss constant due to leaching (yr^{-1})
ksr	=	COPC loss constant due to surface runoff (yr^{-1})
ksv	=	COPC loss constant due to volatilization (yr^{-1})
k_v	=	Water column volatilization rate constant (yr^{-1})
K_v	=	Overall COPC transfer rate coefficient (m/yr)
k_{wt}	=	Overall total water body dissipation rate constant (yr^{-1})
L_{DEP}	=	Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)
L_{Dif}	=	Vapor phase COPC diffusion (dry deposition) load to water body (g/yr)
L_E	=	Soil erosion load (g/yr)
L_R	=	Runoff load from pervious surfaces (g/yr)
L_{RI}	=	Runoff load from impervious surfaces (g/yr)

EQUATION E-1-1

SOIL CONCENTRATION DUE TO DEPOSITION
(SOIL INGESTION EQUATIONS)

Soil Concentration Averaged Over Exposure Duration (for Carcinogens)

$$Cs = \frac{\left\{\frac{Ds \bullet tD - Cs_{tD}}{ks}\right\} + \left\{\frac{Cs_{tD}}{ks} \bullet \left[1 - \exp\left(-ks\left(T_2 - tD\right)\right)\right]\right\}}{\left(T_2 - T_1\right)} \quad for\ T_1 < tD < T_2$$

$$Cs = \frac{Ds}{ks \bullet \left(tD - T_1\right)} \bullet \left\{\left[tD + \frac{\exp\left(-ks \bullet tD\right)}{ks}\right] - \left[T_1 + \frac{\exp\left(-ks \bullet T_1\right)}{ks}\right]\right\} \quad for\ T_2 \le tD$$

Highest Annual Average Soil Concentration (for Noncarcinogens)

$$Cs_{tD} = \frac{Ds \bullet \left[1 - \exp\left(-ks \bullet tD\right)\right]}{ks}$$

where

$$Ds = \frac{100 \bullet Q}{Z_s \bullet BD} \bullet \left[F_v\left(0.31536 \bullet Vdv \bullet Cyv + Dywv\right) + \left(Dydp + Dywp\right) \bullet \left(1 - F_v\right)\right]$$

EQUATION E-1-1 (Continued)

SOIL CONCENTRATION DUE TO DEPOSITION
(SOIL INGESTION EQUATIONS)

Variable	Description	Value and Units
Cs	Average soil concentration over exposure duration	(mg COPC/kg soil)
Cs_{tD}	Soil concentration in time *tD*	(mg COPC/kg soil)
Ds	Deposition term	(mg COPC/kg soil-yr)
tD	Time period over which deposition occurs	100 yr
ks	COPC soil loss constant due to all processes	Calculated using Equation E-1-2 (yr^{-1})
T_2	Length of exposure duration	Child resident, Subsistence Fisher Child, and Subsistence Farmer Child = 6 yr; Adult Resident and Subsistence Fisher = 30 yr; Subsistence Farmer = 40 yr
T_1	Time period at the beginning of combustion	0 yr
100	Units conversion factor	100 mg-cm^2/kg-cm^2
Q	COPC-specific emission rate	See Appendix A (g/s)
Z_s	Soil mixing zone depth	Untilled Soil = 1 cm; Tilled Soil = 20 cm
BD	Soil bulk density	1.5 g soil/cm^3 soil
F_v	Fraction of COPC air concentration in vapor phase	See Appendix C (unitless)
0.31536	Units conversion factor	0.31536 m-g-s/cm-:g-yr
Vdv	Dry deposition velocity	3 cm/s
Cyv	Unitized yearly average air concentration from vapor phase	See Attachment 1 (:g-s/g-m^3)
Dywv	Unitized yearly average wet deposition from vapor phase	See Attachment 1 (s/m^2-yr)

EQUATION E-1-1 (Continued)

SOIL CONCENTRATION DUE TO DEPOSITION
(SOIL INGESTION EQUATIONS)

Variable	Description	Value and Units
Dydp	Unitized yearly average dry deposition from particle phase	See Attachment 1 (s/m^2-yr)
Dywp	Unitized yearly average wet deposition from particle phase	See Attachment 1 (s/m^2-yr)

EQUATION E-1-2

COPC SOIL LOSS CONSTANT
(SOIL INGESTION EQUATIONS)

$$ks = ksg + kse + ksr + ksl + ksv$$

Variable	Description	Value and Units
ks	COPC soil loss constant due to all processes	(yr^{-1})
ksg	COPC loss constant due to biotic and abiotic degradation	See Appendix C (yr^{-1})
kse	COPC loss constant due to soil erosion	0 yr^{-1}
ksr	COPC loss constant due to surface runoff	See Equation E-1-4 (yr^{-1})
ksl	COPC loss constant due to leaching	See Equation E-1-5 (yr^{-1})
ksv	COPC loss constant due to volatilization	0 yr^{-1}

EQUATION E-1-3

SOIL LOSS CONSTANT DUE TO SOIL EROSION
(SOIL INGESTION EQUATIONS)

$$kse = \frac{0.1 \bullet X_e \bullet SD \bullet ER}{BD \bullet Z_s} \bullet \left(\frac{Kd_s \bullet BD}{\Theta_{sw} + \left(Kd_s \bullet BD \right)} \right)$$

Variable	Description	Value and Units
kse	COPC loss constant due to soil erosion	0 yr^{-1}
0.1	Units conversion factor	0.1 g-kg/cm^2-m^2
X_e	Unit soil loss	See Equation E-4-13 (kg/m^2-yr)
SD	Sediment delivery ratio	Calculated using Equation E-1-14 (unitless)
ER	Soil enrichment ratio	Inorganics = 1 (unitless) Organics = 3 (unitless)
BD	Soil bulk density	1.5 g soil/cm^3 soil
Z_s	Soil mixing zone depth	Untilled = 1 cm Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (mL [or cm^3] water/g soil)
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil

EQUATION E-1-4

COPC LOSS CONSTANT DUE TO RUNOFF
(SOIL INGESTION EQUATIONS)

$$ksr = \frac{RO}{\Theta_{sw} \bullet Z_s} \bullet \left(\frac{1}{1 + \left(Kd_s \bullet \frac{BD}{\Theta_{sw}} \right)} \right)$$

Variable	Description	Value and Units
ksr	COPC loss constant due to runoff	(yr^{-1})
RO	Average annual surface runoff from pervious areas	Site-specific (cm/yr)
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil
Z_s	Soil mixing zone depth	Untilled = 1 cm Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (mL [or cm^3] water/g soil)
BD	Soil bulk density	1.5 g soil/cm^3 soil

EQUATION E-1-5

SOIL LOSS CONSTANT DUE TO LEACHING
(SOIL INGESTION EQUATIONS)

$$ksr = \frac{P + I - RO - E_v}{\Theta_{sw} \bullet Z_s \bullet \left[1.0 + \left(\frac{BD \bullet K_d}{\Theta_{sw}} \right) \right]}$$

Variable	Description	Value and Units
ksl	COPC loss constant due to leaching	(yr^{-1})
P	Average annual precipitation	18.06 to 164.19 cm/yr (Site-specific)
I	Average annual irrigation	0 to 100 cm/yr (Site-specific)
RO	Average annual surface runoff from pervious areas	Site-specific (cm/yr)
E_v	Average annual evapotranspiration	35 to 100 cm/yr (Site-specific)
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil
Z_s	Soil mixing zone depth	Untilled = 1 cm Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (cm^3 water/g soil)
BD	Soil bulk density	1.5 g soil/cm^3 soil

EQUATION E-1-6

COPC SOIL LOSS CONSTANT DUE TO VOLATILIZATION
(SOIL INGESTION EQUATIONS)

$$ksv = \left[\frac{3.1536\times10^{7}\bullet H}{Z_s \bullet KD_s \bullet R \bullet T_a \bullet BD}\right] \bullet \left[0.482 \bullet W^{0.78} \bullet \left(\frac{\mu_a}{\rho_a \bullet D_a}\right)^{-0.67} \bullet \left(\sqrt{\frac{4A}{\pi}}\right)^{-0.11}\right]$$

Variable	Description	Value and Units
ksv	COPC soil constant due to volatilization	0 yr^{-1}
0.482	Empirical constant	0.482 (unitless)
0.78	Empirical constant	0.78 (unitless)
-0.67	Empirical constant	-0.67 (unitless)
-0.11	Empirical constant	-0.11 (unitless)
3.1536×10^{7}	Units conversion factor	3.1536×10^{7} s/yr
H	Henry's Law constant	See Appendix C (atm-m^3/mol)
Z_s	Soil mixing zone depth	Untilled = 1 cm; Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (cm^3 water/g soil)
R	Universal gas constant	$8.205x10^{-5}$ atm-m^3/mol-K
T_a	Ambient air temperature	298 K
BD	Soil bulk density	1.5 g soil/cm^3 soil
W	Average annual wind speed	3.9 m/s
μ_a	Viscosity of air	$1.81x10^{-4}$ g/cm-s
ρ_a	Density of air	0.0012 g/cm^3

EQUATION E-1-6 (Continued)

COPC SOIL LOSS CONSTANT DUE TO VOLATILIZATION
(SOIL INGESTION EQUATIONS)

Variable	Description	Value and Units
D_a	Diffusivity of COPC in air	See Appendix C (cm^2/s)
A	Surface area of contaminated area	1.0 m^2

EQUATION E-2-1

SOIL CONCENTRATION DUE TO DEPOSITION
(CONSUMPTION OF ABOVEGROUND PRODUCE EQUATIONS)

Soil Concentration Averaged Over Exposure Duration (for Carcinogens)

$$Cs = \frac{\left\{\frac{Ds \bullet tD - Cs_{tD}}{ks}\right\} + \left\{\frac{Cs_{tD}}{ks} \bullet \left[1 - \exp\left(-ks\left(T_2 - tD\right)\right)\right]\right\}}{T_2 - T_1} \quad \text{for } T_1 < tD < T_2$$

$$Cs = \frac{Ds}{ks \bullet \left(tD - T_1\right)} \bullet \left[\left(tD + \frac{\exp\left(-ks \bullet tD\right)}{ks}\right) - \left(T_1 + \frac{\exp\left(-ks \bullet T_1\right)}{ks}\right)\right] \quad \text{for } T_2 \le tD$$

Highest Average Annual Soil Concentration (for Noncarcinogens)

$$Cs_{tD} = \frac{Ds \bullet \left[1 - \exp\left(-ks \bullet tD\right)\right]}{ks}$$

where

$$Ds = \frac{100 \bullet Q}{Z_s \bullet BD} \bullet \left[F_v\left(0.31536 \bullet Vdv \bullet Cyv + Dywv\right) + \left(Dydp + Dywp\right) \bullet \left(1 - F_v\right)\right]$$

EQUATION E-2-1 (Continued)

SOIL CONCENTRATION DUE TO DEPOSITION
(CONSUMPTION OF ABOVEGROUND PRODUCE EQUATIONS)

Variable	Description	Value and Units
Cs	Average soil concentration over exposure duration	(mg COPC/kg soil)
Cs_{tD}	Soil concentration at time tD	(mg COPC/kg soil)
Ds	Deposition term	(mg COPC/kg soil-yr)
tD	Time period over which deposition occurs	100 yrs
ks	COPC soil loss constant due to all processes	Calculated using Equation E-2-2 (yr^{-1})
T_2	Length of exposure duration	Child Resident, Subsistence Farmer Child, and Subsistence Fisher Child = 6 yrs Adult Resident and Subsistence Fisher = 30 yrs Subsistence Farmer = 40 yrs
T_1	Time period at beginning of combustion	0 yr
100	Units conversion factor	100 mg-cm^2/kg-cm^2
Q	COPC emission rate	See Appendix A (g/s)
Z_s	Soil mixing zone depth	Untilled = 1 cm; Tilled = 20 cm
BD	Soil bulk density	1.5 g soil/cm^3 soil
F_v	Fraction of COPC air concentration in vapor phase	See Appendix C (unitless)
0.31536	Units conversion factor	0.31536 m-g-s/cm-µg-yr
Vdv	Dry deposition velocity	3 cm/s
Cyv	Unitized yearly average air concentration from vapor phase	See Attachment 1 (µg-s/g-m^3)
$Dywv$	Unitized yearly average wet deposition from vapor phase	See Attachment 1 (s/m^2-yr)

EQUATION E-2-1 (Continued)

SOIL CONCENTRATION DUE TO DEPOSITION
(CONSUMPTION OF ABOVEGROUND PRODUCE EQUATIONS)

Variable	Description	Value and Units
Dywp	Unitized yearly average wet deposition from particle phase	See Attachment 1 (s/m^2-yr)
Dydp	Unitized yearly average dry deposition from particle phase	See Attachment 1 (s/m^2-yr)

EQUATION E-2-2

COPC SOIL LOSS CONSTANT
(CONSUMPTION OF ABOVEGROUND PRODUCE EQUATIONS)

$$ks = ksg + kse + ksr + ksl + ksv$$

Variable	Description	Value and Units
ks	COPC soil loss constant due to all processes	(yr^{-1})
ksg	COPC loss constant due to biotic and abiotic degradation	See Appendix C (yr^{-1})
kse	COPC loss constant due to soil erosion	0 yr^{-1}
ksr	COPC loss constant due to surface runoff	Calculated using Equation E-2-4 (yr^{-1})
ksl	COPC loss constant due to leaching	Calculated using Equation E-2-5 (yr^{-1})
ksv	COPC loss constant due to volatilization	Calculated using Equation E-2-6 (yr^{-1})

EQUATION E-2-3

SOIL LOSS CONSTANT DUE TO SOIL EROSION
(CONSUMPTION OF ABOVEGROUND PRODUCE EQUATIONS)

$$kse = \frac{0.1 \bullet X_e \bullet SD \bullet ER}{BD \bullet Z_s} \bullet \left(\frac{Kd_s \bullet BD}{\Theta_{sw} + \left(Kd_s \bullet BD \right)} \right)$$

Variable	Description	Value and Units
kse	COPC loss constant due to soil erosion	0 yr^{-1}
0.1	Units conversion factor	0.1 g-kg/cm^2-m^2
X_e	Unit soil loss	Calculated using Equation E-4-13 (kg/m^2-yr)
SD	Sediment delivery ratio	Calculated using Equation E-4-14 (unitless)
ER	Soil enrichment ratio	Inorganics = 1 (unitless) Organics = 3 (unitless)
BD	Soil bulk density	1.5 g soil/cm^3 soil
Z_s	Soil mixing zone depth	Untilled = 1 cm Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (mL [or cm^3]water/g soil)
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil

EQUATION E-2-4

COPC LOSS CONSTANT DUE TO RUNOFF
(CONSUMPTION OF ABOVEGROUND PRODUCE EQUATIONS)

$$ksr = \frac{RO}{\Theta_{sw} \bullet Z_s} \bullet \left(\frac{1}{1 + \left(Kd_s \bullet \frac{BD}{\Theta_{sw}} \right)} \right)$$

Variable	Description	Value and Units
ksr	COPC loss constant due to runoff	(yr^{-1})
RO	Average annual surface runoff from pervious areas	Site-specific (cm/yr)
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil
Z_s	Soil mixing zone depth	Untilled = 1 cm Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (mL [or cm^3] water/g soil)
BD	Soil bulk density	1.5 g soil/cm^3 soil

EQUATION E-2-5

SOIL LOSS CONSTANT DUE TO LEACHING
(CONSUMPTION OF ABOVEGROUND PRODUCE EQUATIONS)

$$ksr = \frac{P + I - RO - E_v}{\Theta_{sw} \bullet Z_s \bullet \left[1.0 + \left(\frac{BD \bullet K_d}{\Theta_{sw}}\right)\right]}$$

Variable	Description	Value and Units
ksl	COPC loss constant due to leaching	(yr^{-1})
P	Average annual precipitation	18.06 to 164.19 cm/yr (Site-specific)
I	Average annual irrigation	0 to 100 cm/yr (Site-specific)
RO	Average annual surface runoff from pervious areas	Site-specific (cm/yr)
E_v	Average annual evapotranspiration	35 to 100 cm/yr (Site-specific)
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil
Z_s	Soil mixing zone depth	Untilled = 1 cm Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (mL [or cm^3] water/g soil)
BD	Soil bulk density	1.5 g soil/cm^3 soil

EQUATION E-2-6

COPC SOIL LOSS CONSTANT DUE TO VOLATILIZATION
(CONSUMPTION OF ABOVEGROUND PRODUCE EQUATIONS)

$$ksv = \left[\frac{3.1536\times10^{7} \bullet H}{Z_s \bullet KD_s \bullet R \bullet T_a \bullet BD}\right] \bullet \left[0.482 \bullet W^{0.78} \bullet \left(\frac{\mu_a}{\rho_a \bullet D_a}\right)^{-0.67} \bullet \left(\sqrt{\frac{4A}{\pi}}\right)^{-0.11}\right]$$

Variable	Description	Value and Units
ksv	COPC soil constant due to volatilization	0 yr^{-1}
0.482	Empirical constant	0.482 (unitless)
0.78	Empirical constant	0.78 (unitless)
-0.67	Empirical constant	-0.67 (unitless)
-0.11	Empirical constant	-0.11 (unitless)
3.1536×10^{7}	Units conversion factor	3.1536×10^{7} s/yr
H	Henry's Law constant	See Appendix C (atm-m^3/mol)
Z_s	Soil mixing zone depth	Untilled = 1 cm; Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (mL [or cm^3] water/g soil)
R	Universal gas constant	8.205×10^{-5} atm-m^3/mol-K
T_a	Ambient air temperature	298 K
BD	Soil bulk density	1.5 g soil/cm^3 soil
W	Average annual wind speed	3.9 m/s
μ_a	Viscosity of air	1.81×10^{-4} g/cm-s

EQUATION E-2-6 (Continued)

COPC SOIL LOSS CONSTANT DUE TO VOLATILIZATION (CONSUMPTION OF ABOVEGROUND PRODUCE EQUATIONS)

Variable	Description	Value and Units
ρ_a	Density of air	0.0012 g/cm^3
D_a	Diffusivity of COPC in air	See Appendix C (cm^2/s)
A	Surface area of contaminated area	1.0 m^2

EQUATION E-2-7

ABOVEGROUND PRODUCE CONCENTRATION DUE TO DIRECT DEPOSITION (CONSUMPTION OF ABOVEGROUND PRODUCE EQUATIONS)

$$Pd = \frac{1000 \bullet Q \bullet (1 - F_v) \bullet [Dydp + (Fw \bullet Dywp)] \bullet Rp \bullet [1.0 - \exp(-kp \bullet Tp)]}{Yp \bullet kp}$$

Variable	Description	Value and Units
Pd	Concentration of COPC in aboveground produce due to direct (wet and dry) deposition	(mg COPC)
1000	Units conversion factor	1000 mg/g
Q	COPC specific emission rate	See Attachment 1 (g/s)
F_v	Fraction of COPC air concentration in vapor phase	See Appendix C (unitless)
Dydp	Unitized yearly average dry deposition from particle phase	See Attachment 1 (s/m^2-yr)
Rp	Interception fraction of the edible portion of the plant	0.39 (unitless)
Fw	Fraction of COPC wet deposition that adheres to plant surfaces	Anions = 0.2 (unitless) Cations and most Organics = 0.6 (unitless)
Dywp	Unitized yearly wet deposition in particle phase	See Attachment 1 (s/m^2-yr)
kp	Plant surface loss coefficient	18 yr^{-1}
Tp	Length of plant exposure to deposition per harvest of edible plant portion	0.164 yr
Yp	Yield or standing crop biomass of the edible portion of the plant (productivity)	2.24 kg DW/m^2

EQUATION E-2-8

ABOVEGROUND PRODUCE CONCENTRATION DUE TO AIR-TO-PLANT TRANSFER (CONSUMPTION OF ABOVEGROUND PRODUCE EQUATIONS)

$$Pv = Q \bullet F_v \bullet \frac{Cyv \bullet Bv_{ag} \bullet VG_{ag}}{\rho_a}$$

Variable	Description	Value and Units
Pv	Concentration of COPC in aboveground produce due to air-to-plant transfer	µg COPC/g DW (equivalent to mg COPC/kg DW)
Q	COPC-specific emission rate	See Attachment 1 (g/s)
F_v	Fraction of COPC air concentration in vapor phase	See Appendix C (unitless)
Cyv	Unitized yearly average air concentration from vapor phase	See Attachment 1 (µg-s/g-m^3)
BV_{ag}	COPC air-to-plant biotransfer factor for aboveground produce	See Appendix C (unitless); (mg COPC/g DW)/ (mg COPC/g DW)
VG_{ag}	Empirical correction factor for aboveground produce	COPCs with a log $K_{ow} > 4 = 0.01$ (unitless) COPCs with a log $K_{ow} < 4 = 1.0$ (unitless)
ρ_a	Density of air	1200.0 g/m^3

EQUATION E-2-9

ABOVEGROUND PRODUCE CONCENTRATION DUE TO ROOT UPTAKE (CONSUMPTION OF ABOVEGROUND PRODUCE EQUATIONS)

$$Pr_{ag} = Cs \bullet Br_{ag}$$

Variable	Description	Value and Units
Pr_{ag}	Concentration of COPC in aboveground produce due to root uptake	(mg COPC/kg DW)
Cs	Average soil concentration over exposure duration	Calculated using Equation E-2-1 (mg COPC/kg soil)
Br_{ag}	Plant-soil bioconcentration factor for aboveground produce	See Appendix C (unitless); (mg COPC/kg DW plant)/ (mg COPC/kg soil)

EQUATION E-2-10

BELOWGROUND PRODUCE CONCENTRATION DUE TO ROOT UPTAKE (CONSUMPTION OF BELOWGROUND PRODUCE EQUATIONS)

$$Pr_{bg} = Cs \bullet Br_{rootveg} \bullet VG_{rootveg}$$

$$Br_{rootveg} = \frac{RCF}{Kd_s}$$

Variable	Description	Value and Units
Pr_{bg}	Concentration of COPC in belowground produce due to root uptake	(mg COPC/kg DW)
Cs	Average soil concentration over exposure duration	Calculated using Equation E-2-1 (mg COPC/kg soil)
$Br_{rootveg}$	Plant-soil bioconcentration factor for belowground produce	See Appendix C (unitless); (mg COPC/kg plant DW)/(mg COPC/kg soil)
$VG_{rootveg}$	Empirical correction factor for belowground produce	COPCs with a log $K_{ow} > 4$ = 0.01 (unitless) COPCs with a log $K_{ow} < 4$ = 1.0 (unitless)
Kd_s	Soil-water partition coefficient	See Appendix C (cm^3 water/g soil)

EQUATION E-3-1

SOIL CONCENTRATION DUE TO DEPOSITION
(CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

Soil Concentration Averaged Over Exposure Duration (for Carcinogens)

$$Cs = \frac{\left\{\frac{Ds \bullet tD - Cs_{tD}}{ks}\right\} + \left\{\frac{Cs_{tD}}{ks} \bullet \left[1 - \exp\left(-ks\left(T_2 - tD\right)\right)\right]\right\}}{T_2 - T_1} \quad \text{for } T_1 < tD < T_2$$

$$Cs = \frac{Ds}{ks \bullet \left(tD - T_1\right)} \bullet \left[\left(tD + \frac{\exp\left(-ks \bullet tD\right)}{ks}\right) - \left(T_1 + \frac{\exp\left(-ks \bullet T_1\right)}{ks}\right)\right] \quad \text{for } T_2 \le tD$$

Highest Annual Average Soil Concentration (for Noncarcinogens)

$$Cs_{tD} = \frac{Ds \bullet \left[1 - \exp\left(-ks \bullet tD\right)\right]}{ks}$$

where

$$Ds = \frac{100 \bullet Q}{Z_s \bullet BD} \bullet \left[F_v\left(0.31536 \bullet Vdv \bullet Cyv + Dywv\right) + \left(Dydp + Dywp\right) \bullet \left(1 - F_v\right)\right]$$

EQUATION E-3-1 (Continued)

SOIL CONCENTRATION DUE TO DEPOSITION
(CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

Variable	Description	Value and Units
Cs	Average soil concentration over exposure duration	(mg COPC/kg soil)
Cs_{tD}	Soil concentration at time *tD*	(mg COPC/kg soil)
Ds	Deposition term	(mg COPC/kg soil-yr)
tD	Time period over which deposition occurs	100 yrs
ks	COPC soil loss constant due to all processes	Calculated using Equation E-3-2 (yr^{-1})
T_2	Length of exposure duration	Child Resident, Subsistence Farmer Child, and Subsistence Fisher Child = 6 yrs Adult Resident and Subsistence Fisher = 30 yrs Subsistence Farmer = 40 yrs
T_1	Time period at beginning of combustion	0 yr
100	Units conversion factor	100 mg-cm^2/kg-cm^2
Q	COPC emission rate	See Appendix A (g/s)
Z_s	Soil mixing zone depth	Untilled = 1 cm; Tilled = 20 cm
BD	Soil bulk density	1.5 g soil/cm^3 soil
F_v	Fraction of COPC air concentration in vapor phase	0 to 1 (unitless) (See Appendix C)
0.31536	Units conversion factor	0.31536 m-g-s/cm-µg-yr
Vdv	Dry deposition velocity	3 cm/s
Cyv	Unitized yearly average air concentration from vapor phase	See Attachment 1 (µg-s/g-m^3)
Dywv	Unitized yearly average wet deposition from vapor phase	See Attachment 1 (s/m^2/yr)

EQUATION E-3-1 (Continued)

SOIL CONCENTRATION DUE TO DEPOSITION
(CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

Variable	Description	Value and Units
Dywp	Unitized yearly average wet deposition from particle phase	See Attachment 1 ($s/m^2/yr$)
Dydp	Unitized yearly average dry deposition from particle phase	See Attachment 1 ($s/m^2/yr$)

EQUATION E-3-2

COPC SOIL LOSS CONSTANT
(CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

$$ks = ksg + kse + ksr + ksl + ksv$$

Variable	Description	Value and Units
ks	COPC soil loss constant due to all processes	(yr^{-1})
ksg	COPC loss constant due to biotic and abiotic degradation	See Appendix C (yr^{-1})
kse	COPC loss constant due to soil erosion	0 yr^{-1}
ksr	COPC loss constant due to surface runoff	Calculated using Equation E-3-4 (yr^{-1})
ksl	COPC loss constant due to leaching	Calculated using Equation E-3-5 (yr^{-1})
ksv	COPC loss constant due to volatilization	0 yr^{-1}

EQUATION E-3-3

SOIL LOSS CONSTANT DUE TO SOIL EROSION
(CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

$$kse = \frac{0.1 \bullet X_e \bullet SD \bullet ER}{BD \bullet Z_s} \bullet \left(\frac{Kd_s \bullet BD}{\Theta_{sw} + \left(Kd_s \bullet BD \right)} \right)$$

Variable	Description	Value and Units
kse	COPC loss constant due to soil erosion	0 yr^{-1}
0.1	Units conversion factor	0.1 g-kg/cm^2-m^2
X_e	Unit soil loss	Calculated using Equation E-4-13 (kg/m^2-yr)
SD	Sediment delivery ratio	Calculated using Equation E-4-14 (unitless)
ER	Soil enrichment ratio	Inorganics = 1 (unitless) Organics = 3 (unitless)
BD	Soil bulk density	1.5 g soil/cm^3 soil
Z_s	Soil mixing zone depth	Untilled = 1 cm Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (mL [or cm^3] water/g soil)
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil

EQUATION E-3-4

COPC LOSS CONSTANT DUE TO RUNOFF
(CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

$$ksr = \frac{RO}{\Theta_{sw} \bullet Z_s} \bullet \left(\frac{1}{1 + \left(\frac{Kd_s \bullet BD}{\Theta_{sw}} \right)} \right)$$

Variable	Description	Value and Units
ksr	COPC loss constant due to runoff	(yr^{-1})
RO	Average annual surface runoff from pervious areas	Site-specific (cm/yr)
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil
Z_s	Soil mixing zone depth	Untilled = 1 cm Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (mL [or cm^3] water/g soil)
BD	Soil bulk density	1.5 g soil/cm^3 soil

EQUATION E-3-5

SOIL LOSS CONSTANT DUE TO LEACHING
(CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

$$ksr = \frac{P + I - RO - E_v}{\Theta_{sw} \bullet Z_s \bullet \left[1.0 + \left(\frac{BD \bullet K_d}{\Theta_{sw}}\right)\right]}$$

Variable	Description	Value and Units
ksl	COPC loss constant due to leaching	(yr^{-1})
P	Average annual precipitation	18.06 to 164.19 cm/yr (Site-specific)
I	Average annual irrigation	0 to 100 cm/yr (Site-specific)
RO	Average annual surface runoff from pervious areas	Site-specific (cm/yr)
E_v	Average annual evapotranspiration	35 to 100 cm/yr (Site-specific)
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil
Z_s	Soil mixing zone depth	Untilled = 1 cm Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (mL [or cm^3] water/g soil)
BD	Soil bulk density	1.5 g soil/cm^3 soil

EQUATION E-3-6

COPC SOIL LOSS CONSTANT DUE TO VOLATILIZATION (CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

$$ksv = \left[\frac{3.1536\times10^{7} \bullet H}{Z_s \bullet K_{oc} \bullet f_{oc} \bullet R \bullet T_a \bullet BD}\right] \bullet \left[\frac{D_a\left(1-\left[\frac{BD}{\rho_S}\right]-\theta_{SW}\right)}{Z_S}\right]$$

Variable	Description	Value and Units
ksv	COPC soil constant due to volatilization	0 yr^{-1}
3.1536×10^{7}	Units conversion factor	3.1536×10^{7} (s/yr)
H	Henry's Law constant	See Appendix C (atm-m^3/mol)
Z_s	Soil mixing zone depth	Untilled = 1 cm; Tilled = 20 cm
K_{oc}	Organic carbon partition coefficient	See Appendix C (mL/g)
R	Universal gas constant	8.205×10^{-5} atm-m^3/mol-K
f_{oc}	Fraction of organic carbon in soil	See Appendix C (unitless)
T_a	Ambient air temperature	298 K
BD	Soil bulk density	1.5 g soil/cm^3
D_a	Diffusivity of COPC in air	See Appendix C (cm^2/s)
ρ_S	Solids particle density	2.7 g/cm^3
θ_{SW}	Volumetric soil-water content	0.2 (mL/cm^3)

EQUATION E-3-7

FORAGE AND SILAGE CONCENTRATION DUE TO DIRECT DEPOSITION (CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

$$Pd = \frac{1000 \bullet Q \bullet (1 - F_v) \bullet [Dydp + (Fw \bullet Dywp)] \bullet Rp \bullet [1.0 - \exp(-kp \bullet Tp)]}{Yp \bullet kp}$$

Variable	Description	Value and Units
Pd	Concentration of COPC in forage and silage due to direct deposition	(mg COPC/kg DW)
1000	Units conversion factor	1000 mg/g
Q	COPC-specific emission rate	See Appendix A (g/s)
Dydp	Unitized yearly average dry deposition from particle phase	See Attachment 1 (s/m^2-yr)
Fw	Fraction of COPC wet deposition that adheres to plant surfaces	Anions = 0.2 (unitless) Cations and most organics = 0.6 (unitless)
F_v	Fraction of COPC air concentration in vapor phase	See Appendix C (unitless)
Dywp	Unitized yearly average wet deposition from particle phase	See Attachment 1 (s/m^2-yr)
Rp	Interception fraction of the edible portion of the plant	Forage = 0.5 (unitless) Silage = 0.46 (unitless)
kp	Plant surface loss coefficient	18 yr^{-1}
Tp	Length of plant exposure to deposition per harvest of edible portion of plant	Forage = 0.12 yrs Silage = 0.16 yrs
Yp	Yield or standing crop biomass of the edible portion of the plant	Forage = 0.24 kg DW/m^2 Silage = 0.8 kg DW/m^2

EQUATION E-3-8

FORAGE AND SILAGE CONCENTRATION DUE TO AIR-TO-PLANT TRANSFER (CONSUMPTION OF ANIMAL PRODUCTS EQUTATIONS)

$$Pv = Q \bullet F_v \bullet \frac{Cyv \bullet Bv_{forage} \bullet VG_{ag}}{\rho_a}$$

Variable	Description	Value and Units
Pv	Forage and silage concentration due to air-to-plant transfer	(µg COPC/g DW plant tissue [or mg/kg DW])
Q	COPC-specific emission rate	See Appendix A (g/s)
F_v	Fraction of COPC air concentration in vapor phase	See Appendix C (unitless)
Cyv	Unitized yearly average air concentration from vapor phase	See Attachment 1 (µg-s/g-m^3)
Bv_{forage}	Air-to-plant biotransfer for forage and silage	See Appendix C (mg COPC/g plant tissue DW)/(mg COPC/g air)
VG_{ag}	Empirical correction factor for forage and silage	Forage = 1.0 (unitless) Silage = 0.5 (unitless)
ρ_a	Density of air	1200 (g/m^3)

EQUATION E-3-9

FORAGE/SILAGE/GRAIN CONCENTRATION DUE TO ROOT UPTAKE (CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

$$Pr = Cs \bullet Br_{forage}$$

Variable	Description	Value and Units
Pr	Concentration of COPC in forage/silage/grain due to root uptake	(mg COPC/kg DW plant tissue)
Cs	Average soil concentration over exposure duration	Calculated using Equation E-3-1 (mg/kg)
Br_{forage}	Plant-soil bioconcentration factor for forage, silage, and grain	See Appendix C (unitless); (mg COPC/kg plant DW)/(mg COPC/kg soil)]

EQUATION E-3-10

BEEF CONCENTRATION DUE TO PLANT AND SOIL INGESTION (CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

$$A_{beef} = \left(\sum \left(F_i \bullet Qp_i \bullet P_i\right) + Qs \bullet Cs \bullet Bs\right) \bullet Ba_{beef} \bullet MF$$

Variable	Description	Value and Units
A_{beef}	Concentration of COPC in beef	(mg COPC/kg FW tissue)
F_i	Fraction of plant type (i) grown on contaminated soil and ingested by the animal	1 (unitless)
Qp_i	Quantity of plant type (i) ingested by the animal per day	Forage = 8.8 kg DW plant/day Silage = 2.5 Grain = 0.47
P_i	Concentration of COPC in plant type (i) ingested by the animal	Calculated using Equations D-3-7, D-3-8, and D-3-9, and then summed (mg/kg DW)
Qs	Quantity of soil ingested by the animal	0.5 kg/day
Cs	Average soil concentration over exposure duration	Calculated using Equation E-3-1 (mg COPC/kg soil)
Bs	Soil bioavailability factor	1.0 (unitless)
Ba_{beef}	Biotransfer factor for beef	See Appendix C (day/kg FW tissue)
MF	Metabolism factor	0.01 to 1.0 (unitless) (COPC-specific)

EQUAITON E-3-11

MILK CONCENTRATION DUE TO PLANT AND SOIL INGESTION (CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

$$A_{milk} = \left(\sum \left(F_i \bullet Qp_i \bullet P_i\right) + Qs \bullet Cs \bullet Bs\right) \bullet Ba_{milk} \bullet MF$$

Variable	Description	Value and Units
A_{milk}	Concentration of COPC in milk	(mg COPC/kg FW tissue)
F_i	Fraction of plant type (i) grown on contaminated soil and ingested by the animal	1.0 (unitless)
Qp_i	Quantity of plant type (i) ingested by the animal per day	Forage = 13.2 kg DW plant/day Silage = 4.1 kg DW plant/day Grain = 3.0 kg DW plant/day
P_i	Concentration of COPC in plant type (i) ingested by the animal	Calculated using Equations D-3-7, D-3-8, and D-3-9, and then summed (mg/kg DW)
Qs	Quantity of soil ingested by the animal	0.4 kg/day
Cs	Average soil concentration over exposure duration	Calculated using Equation E-3-1 (mg COPC/kg soil)
Bs	Soil bioavailability factor	1.0 (unitless)
Ba_{milk}	Biotransfer factor for milk	See Appendix C (day/kg FW tissue)
MF	Metabolism factor	0.01 to 1.0 (unitless) (COPC-specific)

EQUATION E-3-12

PORK CONCENTRATION DUE TO PLANT AND SOIL INGESTION (CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

$$A_{pork} = \left(\sum \left(F_i \bullet Qp_i \bullet P_i\right) + Qs \bullet Cs \bullet Bs\right) \bullet Ba_{pork} \bullet MF$$

Variable	Description	Value and Units
A_{pork}	Concentration of COPC in pork	(mg COPC/kg FW tissue)
F_i	Fraction of plant type (i) grown on contaminated soil and ingested by the animal	1.0 (unitless)
Qp_i	Quantity of plant type (i) ingested by the animal per day	Silage = 1.4 kg DW plant/day Grain = 3.3 kg DW plant/day
P_i	Concentration of COPC in plant type (i) ingested by the animal	Calculated using Equations D-3-7, D-3-8, and D-3-9, and then summed (mg/kg DW)
Qs	Quantity of soil ingested by the animal	0.37 kg/day
Cs	Average soil concentration over exposure duration	Calculated using Equation E-3-1 (mg COPC/kg soil)
Bs	Soil bioavailability factor	1.0 (unitless)
Ba_{pork}	Biotransfer factor for pork	See Appendix C (day/kg FW tissue)
MF	Metabolism factor	0.01 to 1.0 (unitless) (COPC-specific)

EQUATION E-3-13

COPC CONCENTRATION IN EGGS
(CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

$$A_{egg} = \left(\sum \left(F_i \bullet Qp_i \bullet P_i\right) + Qs \bullet Cs \bullet Bs\right) \bullet Ba_{egg}$$

Variable	Description	Value and Units
A_{egg}	Concentration of COPC in eggs	(mg COPC/kg FW tissue)
F_i	Fraction of plant type (i) grown on contaminated soil and ingested by the animal	1.0 (unitless)
Qp_i	Quantity of plant type (i) ingested by the animal per day	0.2 kg DW plant/day
P_i	Concentration of COPC in plant type (i) ingested by the animal	Calculated using Equation E-3-9 (mg/kg DW)
Qs	Quantity of soil ingested by the animal	0.022 kg/day
Cs	Average soil concentration over exposure duration	Calculated using Equation E-3-1 (mg COPC/kg soil)
Bs	Soil bioavailability factor	1.0 (unitless)
Ba_{egg}	Biotransfer factor for eggs	See Appendix C (day/kg FW tissue)

EQUATION E-3-14

COPC CONCENTRATION IN CHICKEN
(CONSUMPTION OF ANIMAL PRODUCTS EQUATIONS)

$$A_{chicken} = \left(\sum \left(F_i \bullet Qp_i \bullet P_i\right) + Qs \bullet Cs \bullet Bs\right) \bullet Ba_{chicken}$$

Variable	Description	Value and Units
$A_{chicken}$	Concentration of COPC in chicken	(mg COPC/kg FW tissue)
F_i	Fraction of plant type (i) grown on contaminated soil and ingested by the animal	1.0 (unitless)
Qp_i	Quantity of plant type (i) ingested by the animal per day	0.2 kg DW plant/day
P_i	Concentration of COPC in plant type (i) ingested by the animal	Calculated using Equations in D-3-9 (mg COPC/kg DW)
Qs	Quantity of soil ingested by the animal	0.022 kg/day
Cs	Average soil concentration over exposure duration	Calculated using Equation E-3-1 (mg COPC/kg soil)
Bs	Soil bioavailability factor	1.0 (unitless)
$Ba_{chicken}$	Biotransfer factor for chicken	See Appendix C (day/kg FW tissue)

EQUATION E-4-1

WATERSHED SOIL CONCENTRATION DUE TO DEPOSITION
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

Soil Concentration Averaged Over Exposure Duration (for Carcinogens)

$$Cs = \frac{\left\{\frac{Ds \bullet tD - Cs_{tD}}{ks}\right\} + \left\{\frac{Cs_{tD}}{ks} \bullet \left[1 - \exp\left(-ks\left(T_2 - tD\right)\right)\right]\right\}}{T_2 - T_1} \quad \text{for } T_1 < tD < T_2$$

$$Cs = \frac{Ds}{ks \bullet \left(tD - T_1\right)} \bullet \left[\left(tD + \frac{\exp\left(-ks \bullet tD\right)}{ks}\right) - \left(T_1 + \frac{\exp\left(-ks \bullet T_1\right)}{ks}\right)\right] \quad \text{for } T_2 \le tD$$

Highest Average Annual Soil Concentration (for Noncarcinogens)

$$Cs_{tD} = \frac{Ds \bullet \left[1 - \exp\left(-ks \bullet tD\right)\right]}{ks}$$

where

$$Ds = \frac{100 \bullet Q}{Z_s \bullet BD} \bullet \left[F_v\left(0.31536 \bullet Vdv \bullet Cywv + Dywwv\right) + Dywtp \bullet \left(1 - F_v\right)\right]$$

EQUATION E-4-1 (Continued)

WATERSHED SOIL CONCENTRATION DUE TO DEPOSITION
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

Variable	Description	Value and Units
Cs	Average soil concentration over exposure duration	(mg COPC/kg soil)
Cs_{tD}	Soil Concentration at time *tD*	(mg COPC/kg soil)
Ds	Deposition term	(mg COPC/kg soil-yr)
tD	Time period over which deposition occurs	100 yrs
ks	COPC soil loss constant due to all processes	Calculated using Equation E-4-2 (yr^{-1})
T_2	Length of exposure duration	Child Resident, Subsistence Farmer Child, and Subsistence Fisher Child = 6 yrs Adult Resident and Subsistence Fisher = 30 yrs Subsistence Farmer = 40 yrs
T_1	Time period at beginning of combustion	0 yr
100	Units conversion factor	100 mg-cm^2/kg-cm^2
Q	COPC emission rate	See Appendix A (g/s)
Z_s	Soil mixing zone depth	Untilled = 1 cm; Tilled = 20 cm
BD	Soil bulk density	1.5 g soil/cm^3 soil
F_v	Fraction of COPC air concentration in vapor phase	See Appendix C (unitless)
0.31536	Units conversion factor	0.31536 m-g-s/cm-µg-yr
Vdv	Dry deposition velocity	3 cm/s

EQUATION E-4-1 (Continued)

WATERSHED SOIL CONCENTRATION DUE TO DEPOSITION
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

Variable	Description	Value and Units
Cywv	Unitized yearly (water body or watershed) average air concentration from vapor phase	See Attachment 1 ($\mu g\text{-}s/g\text{-}m^3$)
Dywwv	Unitized yearly (water body or watershed) average wet deposition from vapor phase	See Attachment 1 ($s/m^2/yr$)
Dytwp	Unitized yearly (water body or watershed) average total (wet and dry) deposition from particulate phase	See Attachment 1 ($s/m^2/yr$)

EQUATION E-4-2

COPC SOIL LOSS CONSTANT
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$ks = ksg + kse + ksr + ksl + ksv$$

Variable	Description	Value and Units
ks	COPC soil loss constant due to all processes	(yr^{-1})
ksg	COPC loss constant due to biotic and abiotic degradation	See Appendix C (yr^{-1})
kse	COPC loss constant due to soil erosion	0 yr^{-1}
ksr	COPC loss constant due to surface runoff	Calculated using Equation E-4-4 (yr^{-1})
ksl	COPC loss constant due to leaching	Calculated using Equation E-4-5 (yr^{-1})
ksv	COPC loss constant due to volatilization	0 yr^{-1}

EQUATION E-4-3

SOIL LOSS CONSTANT DUE TO SOIL EROSION
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$kse = \frac{0.1 \bullet X_e \bullet SD \bullet ER}{BD \bullet Z_s} \bullet \left(\frac{Kd_s \bullet BD}{\Theta_{sw} + \left(Kd_s \bullet BD \right)} \right)$$

Variable	Description	Value and Units
kse	COPC loss constant due to soil erosion	0 yr^{-1}
0.1	Units conversion factor	0.1 g-kg/cm^2-m^2
X_e	Unit soil loss	Calculated using Equation E-4-13 (kg/m^2-yr)
SD	Sediment delivery ratio	Calculated using Equation E-4-14 (unitless)
ER	Soil enrichment ratio	Inorganics = 1 (unitless) Organics = 20 (unitless)
BD	Soil bulk density	1.5 g soil/cm^3 soil
Z_s	Soil mixing zone depth	Untilled = 1 cm Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (mL [or cm^3] water/g soil)
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil

EQUATION E-4-4

COPC LOSS CONSTANT DUE TO RUNOFF
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$ksr = \frac{RO}{\Theta_{sw} \bullet Z_s} \bullet \left(\frac{1}{1 + \left(\frac{Kd_s \bullet BD}{\Theta_{sw}} \right)} \right)$$

Variable	Description	Value and Units
ksr	COPC loss constant due to runoff	(yr^{-1})
RO	Average annual surface runoff from pervious areas	Site-specific (cm/yr)
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil
Z_s	Soil mixing zone depth	Untilled = 1 cm; Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (mL [or cm^3] water/g soil)
BD	Soil bulk density	1.5 g soil/cm^3 soil

EQUATION E-4-5

SOIL LOSS CONSTANT DUE TO LEACHING
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$ksr = \frac{P + I - RO - E_v}{\Theta_{sw} \bullet Z_s \bullet \left[1.0 + \left(\frac{BD \bullet K_d}{\Theta_{sw}}\right)\right]}$$

Variable	Description	Value and Units
ksl	COPC loss constant due to leaching	(yr^{-1})
P	Average annual precipitation	18.06 to 164.19 (cm/yr) (Site-specific)
I	Average annual irrigation	0 to 100 (cm/yr) (Site-specific)
RO	Average annual surface runoff from pervious areas	Site-specific (cm/yr)
E_v	Average annual evapotranspiration	35 to 100 (cm/yr) (Site-specific)
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil
Z_s	Soil mixing zone depth	Untilled = 1 cm Tilled = 20 cm
Kd_s	Soil-water partition coefficient	See Appendix C (cm^3 water/g soil)
BD	Soil bulk density	1.5 g soil/cm^3 soil

EQUATION E-4-6

COPC SOIL LOSS CONSTANT DUE TO VOLATILIZATION
(CONSUMPTION OF FISH AND DRINKING WATER EQUATIONS)

$$ksv = \left[\frac{3.1536\times10^{7} \bullet H}{Z_S \bullet Kd_S \bullet R \bullet T_a \bullet BD}\right] \bullet \left[0.482 \bullet W^{0.78} \bullet \left(\frac{\mu_a}{\rho_a \bullet D_a}\right)^{-0.67} \bullet \left(\sqrt{\frac{4A}{\pi}}\right)^{-0.11}\right]$$

Variable	Description	Value and Units
ksv	Constant for COPC loss due to volatilization	0 yr^{-1}
3.1536x10^7	Units conversion factor	3.1536x10^7 s/yr
0.482	Empirical constant	0.482 (unitless)
0.78	Empirical constant	0.78 (unitless)
-0.67	Empirical constant	-0.67 (unitless)
-0.11	Empirical constant	-0.11 (unitless)
3.1536×10^7	units conversion factor	3.1536×10^7 (s/yr)
H	Henry's Law constant	See Appendix C (atm-m^3/mol)
Z_S	Soil mixing zone depth	Untilled = 1 cm; Tilled = 20 cm
Kd_S	Soil-water partition coefficient	See Appendix C (mL/g)
R	Universal gas constant	8.205×10^{-5} (atm-m^3/mol-K)
T_a	Ambient air temperature	298 K
BD	Bulk density of soil	1.5 g/cm^3
W	Average annual wind speed	3.9 m/s
μ_a	Viscosity of air	1.81x10^{-4}

EQUATION E-4-6 (Continued)

COPC SOIL LOSS CONSTANT DUE TO VOLATILIZATION
(CONSUMPTION OF FISH AND DRINKING WATER EQUATIONS)

Variable	Description	Value and Units
ρ_a	Density of air	0.0012 g/cm^3
D_a	Diffusion coefficient of contaminant in air	See Appendix C cm^2/s
A	Surface area of contaminated area	1.0 m^2

EQUATION E-4-7

TOTAL WATER BODY LOAD
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$L_T = L_{DEP} + L_{dif} + L_{RI} + L_R + L_E$$

Variable	Description	Value and Units
L_T	Total COPC load to the water body	(g/yr)
L_{DEP}	Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body	Calculated using Equation E-4-8 (g/yr)
L_{dif}	Vapor phase COPC diffusion (dry deposition) load to water body	Calculated using Equation E-4-12 (g/yr)
L_{RI}	Runoff load from impervious surfaces	Calculated using Equation E-4-9 (g/yr)
L_R	Runoff load from pervious surfaces	Calculated using Equation E-4-10 (g/yr)
L_E	Soil erosion load	Calculated using Equation E-4-11 (g/yr)

EQUATION E-4-8

DEPOSITION TO WATER BODY
(CONSUMPTION OF DRINKING WATER AND FISH EQUAITONS)

$$L_{DEP} = Q \bullet \left[F_v \bullet Dywwv + \left(1.0 - F_v\right) \bullet Dytwp \right] \bullet A_w$$

Variable	Description	Value and Units
L_{DEP}	Total (wet and dry) particle phase and wet vapor phase direct deposition load to water body	(g/yr)
Q	COPC specific emission rate	See Appendix A (g/s)
F_v	Fraction of COPC air concentration in vapor phase	See Appendix C (unitless)
Dywwv	Unitized yearly (water body or watershed) average wet deposition from particle phase	See Attachment 1 (s/m^2-yr)
Dytwp	Unitized yearly (water body or watershed) average total (wet and dry) deposition from vapor phase	See Attachment 1 (s/m^2-yr)
A_w	Water body surface area	See Attachment 1 (m^2)

EQUATION E-4-9

IMPERVIOUS RUNOFF LOAD TO WATER BODY
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$L_{RI} = Q \bullet \left[F_v \bullet Dywwv + \left(1.0 - F_v\right) \bullet Dytwp \right] \bullet A_I$$

Variable	Description	Value and Units
L_{RI}	Runoff load from impervious surfaces	(g/yr)
Q	COPC specific emission rate	See Appendix A (g/s)
F_v	Fraction of COPC air concentration in vapor phase	See Appendix C (unitless)
Dywwv	Unitized yearly (water body or watershed) average wet deposition from vapor phase	See Attachment 1 (s/m^2-yr)
Dytwp	Unitized yearly (water body or watershed) average total (wet and dry) deposition from particle phase	See Attachment 1 (s/m^2-yr)
A_I	Impervious watershed area receiving COPC deposition	Site-specific (m^2)

EQUATION E-4-10

PERVIOUS RUNOFF LOAD TO WATER BODY
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$L_R = RO \bullet \left(A_L - A_I\right) \bullet \frac{Cs \bullet BD}{\Theta_{sw} + Kd_s \bullet BD} \bullet 0.01$$

Variable	Description	Value and Units
L_R	Runoff load from pervious surfaces	(g/yr)
RO	Average annual surface runoff from pervious areas	Site-specific (cm/yr)
A_L	Total watershed area receiving COPC deposition	Site-specific (m^2)
A_I	Impervious watershed area receiving COPC deposition	Site-specific (m^2)
Cs	Average soil concentration over exposure duration	Calculated using Equation E-4-1 (mg COPC/kg soil)
BD	Soil bulk density	1.5 g soil/cm^3 soil
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil
Kd_s	Soil-water partition coefficient	See Appendix C (cm^3 water/g soil)
0.01	Units conversion factor	0.01 kg-cm^2/mg-m^2

EQUATION E-4-11

EROSION LOAD TO WATER BODY
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$L_E = X_e \bullet \left(A_L - A_I\right) \bullet SD \bullet ER \bullet \frac{Cs \bullet Kd_s \bullet BD}{\Theta_{sw} + Kd_s \bullet BD} \bullet 0.001$$

Variable	Description	Value and Units
L_E	Soil erosion load	(g/yr)
X_e	Unit soil loss	Calculated using Equation E-4-13 (kg/m^2-yr)
A_L	Total watershed area receiving deposition	Site-specific (m^2)
A_I	Area of impervious watershed receiving deposition	Site-specific (m^2)
SD	Watershed sediment delivery ratio	Calculated using Equation E-4-14 (unitless)
ER	Soil enrichment ratio	Inorganic COPCs = 1 (unitless) Organic COPCs = 3 (unitless)
Cs	Average soil concentration over exposure duration	Calculated using Equation E-4-1 (mg COPC/kg soil)
Kd_s	Soil-water partition coefficient	See Appencix C (mL [or cm^3] water/g soil)
BD	Soil bulk density	1.5 g/cm^3
Θ_{sw}	Soil volumetric water content	0.2 mL water/cm^3 soil
0.001	Units conversion factor	0.001 kg-cm^2/mg-m^3

EQUATION E-4-12

DIFFUSION LOAD TO WATER BODY
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$L_{dif} = \frac{K_v \bullet Q \bullet F_v \bullet Cywv \bullet A_w \bullet 1 \times 10^{-6}}{\frac{H}{R \bullet T_{wk}}}$$

Variable	Description	Value and Units
L_{dif}	Dry vapor phase diffusion load to water body	(g/yr)
K_v	Overall transfer rate coefficient	Calculated using Equation E-4-19 (m/yr)
Q	COPC specific emission rate	See Appendix A (g/s)
F_v	Fraction of COPC air concentration in vapor phase	See Appendix C (unitless)
$Cywv$	Unitized yearly watershed air concentration from vapor phase	See Attachment 1 (µg-s/g-m^3)
A_w	Water body surface area	Site-specific (m^2)
10^{-6}	Units conversion factor	10^{-6} g/µg
H	Henry's Law constant	See Appendix C (atm-m^3/mol)
R	Universal gas constant	8.205x10-5 atm-m^3/mol-K
T_{wk}	Water body temperature	298 K

EQUATION E-4-13

UNIVERSAL SOIL LOSS EQUATION (USLE)
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$X_e = RF \bullet K \bullet LS \bullet C \bullet PF \bullet \frac{907.18}{4047}$$

Variable	Description	Value and Units
X_e	Unit soil loss	(kg/m^2-yr)
RF	USLE rainfall (or erosivity) factor	50 to 300 yr^{-1} (Site-specific)
K	USLE erodibility factor	Site-specific (ton/acre)
LS	USLE length-slope factor	Site-specific (unitless)
C	USLE cover management factor	Site-specific (unitless)
PF	USLE supporting practice factor	Site-specific (unitless)
907.18	Units conversion factor	907.18 kg/ton
4047	Units conversion factor	4047 m^2/acre

EQUATION E-4-14

SEDIMENT DELIVERY RATIO
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$SD = a \bullet \left(A_L\right)^{-b}$$

Variable	Description	Value and Units
SD	Watershed sediment delivery ratio	(unitless)
a	Empirical intercept coefficient	Watershed Area (sq.miles) / "*a*" Coefficient (unitless) 0.1 / 2.1 1.0 / 1.9 10 / 1.4 100 / 1.2 1,000 / 0.6
A_L	Total watershed area receiving deposition	Site-specific (m^2)
b	Empirical slope coefficient	0.125 (unitless)

EQUATION E-4-15

TOTAL WATER BODY CONCENTRATION
(CONSUMPTION OF DRINKING WATER AND FISH CONCENTRATIONS)

$$C_{wtot} = \frac{L_T}{Vf_x \bullet f_{wc} \bullet k_{wt} \bullet A_w \bullet \left(d_{wc} + d_{bs}\right)}$$

Variable	Description	Value and Units
C_{wtot}	Total water body COPC concentration, including water column and bed sediment	(g COPC/m^3 water body [equivalent to mg COPC/L water body])
L_T	Total COPC load to the water body, including deposition, runoff, and erosion	Calculated using Equation E-4-7 (g/yr)
Vf_x	Average volumetric flow rate through water body	Site-specific (m^3/yr)
f_{wc}	Fraction of water body COPC concentration in the water column	0 to 1(unitless); Calculated using Equation E-4-16
k_{wt}	Overall total water body dissipation rate constant	Calculated using Equation E-4-17 (yr^{-1})
A_w	Water body surface area	Site-specific (m^2)
d_{wc}	Depth of water column	Site-specific (m)
d_{bs}	Depth of upper benthic sediment layer	0.03 m

EQUATION E-4-16

FRACTION IN WATER COLUMN AND BENTHIC SEDIMENT (CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$f_{wc} = \frac{\left(1 + Kd_{sw} \bullet TSS \bullet 1 \times 10^{-6}\right) \bullet d_{wc} / d_z}{\left(1 + Kd_{sw} \bullet TSS \bullet 1 \times 10^{-6}\right) + d_{wc} / d_z + \left(\Theta_{bs} + KD_{bs} \bullet C_{BS}\right) \bullet d_{bs} / d_z}$$

$$f_{bs} = 1 - f_{wc}$$

Variable	Description	Value and Units
f_{wc}	Fraction of total water body COPC concentration in the water column	(unitless)
f_{bs}	Fraction of total water body COPC concentration in benthic sediment	(unitless)
Kd_{sw}	Suspended sediment/surface water partition coefficient	See Appendix C (L [or cm^3] water/kg suspended sediment)
TSS	Total suspended solids concentrations	2 to 300 mg/L (Site-specific)
1×10^{-6}	Units conversion factor	1×10^{-6} kg/mg
d_{wc}	Depth of water column	Site-specific (m)
d_{bs}	Depth of upper benthic sediment layer	0.03 m
d_z	Total water body depth	Calculated using Equation E-4-26 (m)
C_{BS}	Bed sediment concentration (or bed sediment bulk density)	1.0 g/cm^3 (or kg/L)
Θ_{bs}	Bed sediment porosity	0.6 $L_{water}/L_{sediment}$
Kd_{bs}	Bed sediment/sediment pore water partition coefficient	See Appendix C (L [or cm^3] water/kg bottom sediment)

EQUATION E-4-17

OVERALL TOTAL WATER BODY DISSIPATION RATE CONSTANT (CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$k_{wt} = f_{wc} \bullet k_v + f_{bs} \bullet k_b$$

Variable	Description	Value and Units
k_{wt}	Overall total water body dissipation rate constant	(yr^{-1})
f_{wc}	Fraction of total water body COPC concentration in the water column	Calculated using Equation E-4-16 (unitless)
k_v	Water column volatilization rate constant	Calculated using Equation E-4-18 (yr^{-1})
f_{bs}	Fraction of total water body COPC concentration in benthic sediment	Calculated using Equation E-4-16 (unitless)
k_b	Benthic burial rate constant	Calculated using Equation E-4-22 (yr^{-1})

EQUATION E-4-18

WATER COLUMN VOLATILIZATION LOSS RATE CONSTANT
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$k_v = \frac{K_v}{d_z \bullet \left(1 + Kd_{sw} \bullet TSS \bullet 1 \times 10^{-6}\right)}$$

Variable	Description	Value and Units
k_v	Water column volatilization rate constant	(yr^{-1})
K_v	Overall COPC transfer rate coefficient	Calculated using Equation E-4-19 (m/yr)
Kd_{sw}	Suspended sediment/surface water partition coefficient	See Appendix C (L water/kg suspended sediments)
d_z	Total water body depth	Calculated using Equation E-4-26 (m)
TSS	Total suspended solids concentration	2 to 300 mg/L (Site-specific)
1×10^{-6}	Units conversion factor	1×10^{-6} kg/mg

EQUATION E-4-19

OVERALL COPC TRANSFER RATE COEFFICIENT
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$K_v = \left[K_L^{-1} + \left(K_G \bullet \frac{H}{R \bullet T_{wk}} \right)^{-1} \right]^{-1} \bullet \Theta^{(T_{wk}-293)}$$

Variable	Description	Value and Units
K_v	Overall COPC transfer rate coefficient	(m/yr)
K_L	Liquid phase transfer coefficient	Calculated using Equation E-4-20 (m/yr)
K_G	Gas phase transfer coefficient	Calculated using Equation E-4-21 (m/yr)
H	Henry's Law constant	See Appendix C (atm-m^3/mol)
R	Universal gas constant	8.205×10^{-5} atm-m^3/mol-K
T_{wk}	Water body temperature	298 K
Θ	Temperature correction factor	1.026 (unitless)

EQUATION E-4-20

LIQUID PHASE TRANSFER COEFFICIENT
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

For flowing streams or rivers

$$K_L = \sqrt{\frac{\left(1\times10^{-4}\right)\bullet D_W \bullet u}{d_z}} \bullet 3.1536\times10^{7}$$

For quiescent lakes or ponds

$$K_L = \left(C_d^{0.5} \bullet W\right)\bullet\left(\frac{\rho_a}{\rho_w}\right)^{0.5} \bullet \frac{k^{0.33}}{\lambda_z}\bullet\left(\frac{\mu_w}{\rho_w \bullet D_w}\right)^{-0.67} \bullet 3.1536\times10^{7}$$

Variable	Description	Value and Units
K_L	Liquid phase transfer coefficient	(m/yr)
D_w	Diffusivity of COPC in water	See Appendix C (cm^2/s)
U	Current velocity	Site-specific (m/s)
d_Z	Total water body depth	Calculated using Equation E-4-26 (m)
3.1536×10^7	Units conversion factor	3.1536×10^7 s/yr
C_d	Drag coefficient	0.0011 (unitless)
W	Average annual wind speed	3.9 m/s
ρ_a	Density of air	0.0012 g/cm^3
ρ_w	Density of water	1 g/cm^3

EQUATION E-4-20 (Continued)

LIQUID PHASE TRANSFER COEFFICIENT
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

Variable	Description	Value and Units
k	von Karman's constant	0.4 (unitless)
λ_z	Dimensionless viscous sublayer thickness	4 (unitless)
μ_w	Viscosity of water corresponding to water temperature	1.69×10^{-2} g/cm-s

EQUATION E-4-21

GAS PHASE TRANSFER COEFFICIENT
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

For streams and rivers

$$K_G = 36500\, m/yr$$

Quiescent lakes or ponds

$$K_G = \left(C_d^{\,0.5} \bullet W\right) \bullet \frac{k^{0.33}}{\lambda_z} \bullet \left(\frac{\mu_a}{\rho_a \bullet D_a}\right)^{-0.67} \bullet 3.1536 \times 10^7$$

Variable	Description	Value and Units
K_G	Gas phase transfer coefficient	(m/yr)
C_d	Drag coefficient	0.0011 (unitless)
W	Average annual wind velocity	3.9 m/s
k	von Karman's constant	0.4 (unitless)
λ_z	Dimensionless viscous sublayer thickness	4 (unitless)
μ_a	Viscosity of air	1.81×10^{-4} g/cm-s
ρ_a	Density of air	0.0012 g/cm^3
D_a	Diffusivity of COPC in air	See Appendix C (cm^2/s)
3.1536×10^7	Units conversion factor	3.1536×10^7 s/yr

EQUATION E-4-22

BENTHIC BURIAL RATE CONSTANT
(CUNSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$k_b = \left(\frac{X_e \bullet A_L \bullet SD \bullet 1 \times 10^3 - Vf_x \bullet TSS}{A_w \bullet TSS} \right) \bullet \left(\frac{TSS \bullet 1 \times 10^{-6}}{C_{BS} \bullet d_{bs}} \right)$$

Variable	Description	Value and Units
k_b	Benthic burial rate constant	(yr^{-1})
X_e	Unit soil loss	Calculated using Equation E-4-13 (kg/m^2-yr)
A_L	Total watershed area receiving deposition	Site-specific (m^2)
SD	Watershed sediment delivery ratio	Calculated using Equation E-4-14 (unitless)
1×10^3	Units conversion factor	1×10^3 g/kg
Vf_x	Average volumetric flow rate through water body	Site-specific (m^3/yr)
TSS	Total suspended solids concentration	2 to 300 mg/L (Site-specific)
A_w	Water body surface area	Site-specific (m^2)
1×10^{-6}	Units conversion factor	1×10^{-6} kg/mg
C_{BS}	Bed sediment concentration	1.0 g/cm^3
d_{bs}	Depth of upper benthic sediment layer	0.03 m

EQUATION E-4-23

TOTAL WATER BODY CONCENTRATION
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$C_{wctot} = f_{wc} \bullet C_{wtot} \bullet \frac{d_{wc} + d_{bs}}{d_{wc}}$$

Variable	Description	Value and Units
C_{wctot}	Total COPC concentration in water column	(mg COPC/L water column)
f_{wc}	Fraction of total water body COPC concentration in the water column	Calculated using Equation E-4-16 (unitless)
C_{wtot}	Total waterbody COPC concentration including water body and bed sediment	Calculated using Equation E-4-15 (mg COPC/L water body [or g COPC/m^3 water body])
d_{wc}	Depth of water column	Site-specific (m)
d_{bs}	Depth of upper benthic sediment layer	0.03 m

EQUATION E-4-24

DISSOLVED WATER PHASE CONCENTRATION
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$C_{dw} = \frac{C_{wctot}}{1 + Kd_{sw} \bullet TSS \bullet 1 \times 10^{-6}}$$

Variable	Description	Value and Units
C_{dw}	Dissolved water phase concentration	(mg COPC/L water)
C_{wctot}	Total COPC concentration in water column	Calculated using Equation E-4-23 (mg COPC/L water column)
Kd_{sw}	Suspended sediments/surface water partition coefficient	See Appendix C (L water/kg suspended sediment)
TSS	Total suspended solids concentration	2 to 300 mg/L (Site-specific)
1×10^{-6}	Units conversion factor	1×10^{-6} kg/mg

EQUATION E-4-25

COPC CONCENTRATION SORBED TO BED SEDIMENT
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$C_{sb} = f_{bs} \bullet C_{wtot} \bullet \frac{Kd_{bs}}{\Theta_{bs} + Kd_{bs} \bullet C_{BS}} \bullet \frac{d_{wc} + d_{bs}}{d_{bs}}$$

Variable	Description	Value and Units
C_{sb}	Concentration sorbed to bed sediment	(mg COPC/kg sediment)
f_{bs}	Fraction of total water body COPC concentration that occurs in the benthic sediment	Calculated using Equation E-4-16 (unitless)
C_{wtot}	Total water body concentration including water column and bed sediment	Calculated using Equation E-4-15 (mg COPC/ L water body [or g COPC/cm^3 water body])
Kd_{bs}	Bed sediment/sediment pore water partition coefficient	See Appendix C (L water/kg bed sediment [or cm^3 water/g bed sediment])
Θ_{bs}	Bed sediment porosity	0.6 (unitless [$L_{\text{pore volume}}/L_{\text{sediment}}$])
C_{BS}	Bed sediment concentration (or sediment bulk density)	1.0 g/cm^3
d_{wc}	Depth of water column	Site-specific (m)
d_{bs}	Depth of upper benthic sediment layer	0.03 m

EQUATION E-4-26

TOTAL WATER BODY DEPTH
(CONSUMPTION OF DRINKING WATER AND FISH EQUATIONS)

$$d_Z = d_{WC} + d_{bs}$$

Variable	Description	Value and Units
d_z	Total water body depth	Site-specific (m)
d_{wc}	Depth of water column	Site-specific (m)
d_{bs}	Depth of upper benthic sediment layer	0.03 m

EQUATION E-4-27

FISH CONCENTRATION FROM BIOCONCENTRATION FACTORS USING DISSOLVED PHASE WATER CONCENTRATION (CONSUMPTION OF FISH EQUATIONS)

$$C_{fish} = C_{dw} \bullet BCF_{fish}$$

Variable	Description	Value and Units
C_{fish}	Concentration of COPC in fish	(mg COPC/kg FW tissue)
C_{dw}	Dissolved phase water concentration	Calculated using E-4-24 (mg COPC/L)
BCF_{fish}	Bioconcentration factor for COPC in fish	See Appendix C (unitless); ([mg COPC/kg FW tissue]/[mg COPC/kg feed])

EQUATION E-4-28

FISH CONCENTRATION FROM BIOACCUMULATION FACTORS USING DISSOLVED PHASE WATER CONCENTRATION (CONSUMPTION OF FISH EQUATIONS)

$$C_{fish} = C_{dw} \bullet BAF_{fish}$$

Variable	Description	Value and Units
C_{fish}	Concentration of COPC in fish	(mg COPC/kg FW tissue)
C_{dw}	Dissolved phase water concentration	Calculated using Equation E-4-24 (mg COPC/L)
BAF_{fish}	Bioaccumulation factor for COPC in fish	See Appendix C (L/kg FW tissue)

EQUATION E-4-29

FISH CONCENTRATION FROM BIOTA-TO-SEDIMENT ACCUMULATION FACTORS USING COPC SORBED TO BED SEDIMENT (CONSUMPTION OF FISH EQUATIONS)

$$C_{fish} = \frac{C_{sb} \bullet f_{lipid} \bullet BSAF}{OC_{sed}}$$

Variable	Description	Value and Units
C_{fish}	Concentration of COPC in fish	(mg COPC/kg FW tissue)
C_{sb}	Concentration of COPC sorbed to bed sediment	Calculated using Equation E-4-25 (mg COPC/kg bed sediment)
f_{lipid}	Fish lipid content	0.07 (unitless)
$BSAF$	Biota-to-sediment accumulation factor	See Appendix C (unitless); ([mg COPC/kg lipid tissue]/[mg COPC/kg sediment])
OC_{sed}	Fraction of organic carbon in bottom sediment	0.04 (unitless)

EQUATION E-5-1

AIR CONCENTRATION
(DIRECT INHALATION EQUATION)

$$C_a = Q \bullet \left[F_v \bullet Cyv + \left(1.0 - F_v\right) \bullet Cyp \right]$$

Variable	Description	Value and Units
C_a	Air concentration	($\mu g/m^3$)
Q	COPC-specific emission rate	See Appendix A (g/s)
F_v	Fraction of COPC air concentration in vapor phase	See Appendix C (unitless)
Cyv	Unitized yearly air concentration from vapor phase	See Attachment 1 ($\mu g\text{-}s/g\text{-}m^3$)
Cyp	Unitized yearly air concentration from particle phase	See Attachment 1 ($\mu g\text{-}s/g\text{-}m^3$)

EQUATION E-6-1

ACUTE AIR CONCENTRATION EQUATION
(ACUTE EQUATION)

$$C_{acute} = Q \bullet \left[F_v \bullet Chv + \left(1.0 - F_v\right) \bullet Chp \right]$$

Variable	Description	Value and Units
C_{acute}	Acute air concentration	($\mu g/m^3$)
Q	COPC-specific emission rate	See Appendix A (g/s)
F_v	Fraction of COPC air concentration in vapor phase	See Appendix C (unitless)
Chv	Unitized hourly air concentration from vapor phase	See Attachment 1 (μg-s/g-m^3)
Chp	Unitized hourly air concentration from particle phase	See Attachment 1 (μg-s/g-m^3)